

RELIABILITY



DRUM RELIABILITY STARTS WITH NO-HEAD-CONTACT DESIGN! And only Bryant's Auto-Lift drums have a built-in assurance that their flying heads can *never* touch the recording surface during drum start-up and run-down periods. This fail-safe operation is obtained by using a simple, self-regulated centrifugal mechanism to move the drum up to and away from the heads during start/stop cycles. □ Supplementing this inherent drum reliability is the high confidence level of Bryant's Uni-Just flying heads, aerodynamically-designed and precision-built to maintain the most effective head-to-media gap without skipping or bouncing. Besides *optimum reliability*, Auto-Lift drums offer high-performance plated magnetic media and are available in the widest range of capacities—up to 35,000,000 bits! □ These features—plus an exhaustive product assurance program, complete electronic systems capability and specially-designed drums—are the reasons why Bryant is the world's leading independent supplier of memory drums and disc files. □ See for yourself by writing for Drum Brochure No. 102-11-63 and Disc File Brochure No. BCPB-101-9-63.



COMPUTER PRODUCTS

850 LADD ROAD • WALLED LAKE, MICHIGAN

A Division of Ex-Cell-O Corporation

64-BMD-1-4

PERFORMANCE



see for yourself!

ELECTRONIC INTERFACES DESIGNED AND BUILT BY BRYANT OPTIMIZE DRUM SYSTEM PERFORMANCE—even when the customer has had little or no experience in magnetic recording technology! Complete systems—either custom-designed or built up from versatile standard designs—can be produced to meet a customer's interface specifications of data rate, capacity, control signals and mode of operation. □ Complex serial and parallel systems have been built containing address decoding, counters, shift registers, parity generation and checking, and logic level and error alarms. Drums now operating in customer installations utilize up to 50-bit parallel recording, precession loops, real-time delays, and read/write loop registers capable of giving access times down to 1.67 milliseconds. □ All systems are designed around Bryant's complete line of Series 8000 Electronic Circuit Modules. These circuits provide all required read, write, clocking, head switching, logic and power control functions. □ *See for yourself!* Write our Information Services Department for Auto-Lift Drum Brochure number BCPB-102-4-64-R2 and data sheets on Read Amplifier 8005, Write Amplifier 8010, Single Head Select 8020, Multi-Head Select 8025, Nand Circuit 8050, Gate Driver 8060, and Read Mode Switch 8090.

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64-BMD-2-9

FLEXIBILITY



see for yourself!

ONLY BRYANT SERIES 4000 DISC FILES OFFER UNRESTRICTED PARALLEL-FORMATING CAPABILITY. Buy Bryant and you buy ultra-reliable parallel transfer of data from the largest-capacity, high-speed random-access memory in existence! For example, one Bryant customer has effected 28-bit parallel operation on a Series 4000 Disc File without complicated and expensive de-skewing buffers. Instantaneous bit transfer rates range up to 7.11 megacycles; data is transferred at an instantaneous rate of 125,000 28-bit words a second. □ All this has been accomplished at the extraordinarily low error rate of one recoverable error in 10^{11} bits processed. At a single customer facility, a bank of seven Series 4000 Disc Files operates on-line in the parallel mode with an average of 1200 hours mean-time-between-failures; the maximum value ranges up to 3,000 hours. However, this performance does not represent the full capability of a Series 4000 Disc File. □ *See for yourself,* write our Information Services Department for Series 4000 Disc File brochure No. BCPB-101-4-64-R1 and/or article reprint entitled "Criteria for Selecting Random-Access Mass Memories," No. BCAR-101-4-64.

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64-BDF-2-10

CAPACITY



see for yourself!

BRITANNICA RELIABILITY AND STORAGE CAPACITY AVAILABLE IN BRYANT SERIES 4000 DISC FILES! The information reference standard of the world—the Encyclopedia Britannica—contains over 40 million words in a fixed, unchangeable format. Bryant's Series 4000 Disc Files offer the same optimum reliability and even more data storage capacity (up to 1.6 billion bits, equivalent to 46 million words), but also has the capability of random-access input/output and a flexible format with alterable content. □ Add to this an average access time of 125 milliseconds (includes positioning, verification and latency times) to retrieve any bit of stored data and you have the reason why the world's leading manufacturers of computers and data handling equipment specify *only Bryant*. □ *See for yourself why* Bryant is the leading independent supplier of magnetic storage disc files and drums. □ *See for yourself,* write for the Series 4000 Disc File brochure No. BCPB-101-9-63 or Auto-Lift Drum brochure No. BCPB-102-11-63.

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A Division of Ex-Cell-O Corporation

64-BDF-1-3

ECONOMY



See for yourself!

1¢ BUYS 122 BITS!

Bit-by-bit . . . and at only 0.0082 cents each . . . Bryant Series 4000 Disc Files are the *most reliable* mass memory storage device available, provide the *widest capacity range*—31 million to 1.6 billion bits—in economic machine sizes, and have the *greatest flexibility* because they handle parallel or series operations in any recording mode. *See for yourself*, write for details.





BRYANT
COMPUTER PRODUCTS
850 Ladd Road
Walled Lake, Michigan
A Division of Ex-Cell-O Corporation
64-BNP-1-3

All the virtues noted in the headlines above apply equally well to all Bryant rotating magnetic memories and memory systems. Throughout 1964, the ads shown here have stressed that Bryant products possess: **Built-in Reliability** because they are made as simply as possible. And this design concept is backed up with a professional product assurance program encompassing both the quality control and reliability engineering functions.

State-of-the-art performance—a natural consequence of a product planning philosophy which has made Bryant the leading independent manufacturer of rotating magnetic memories.

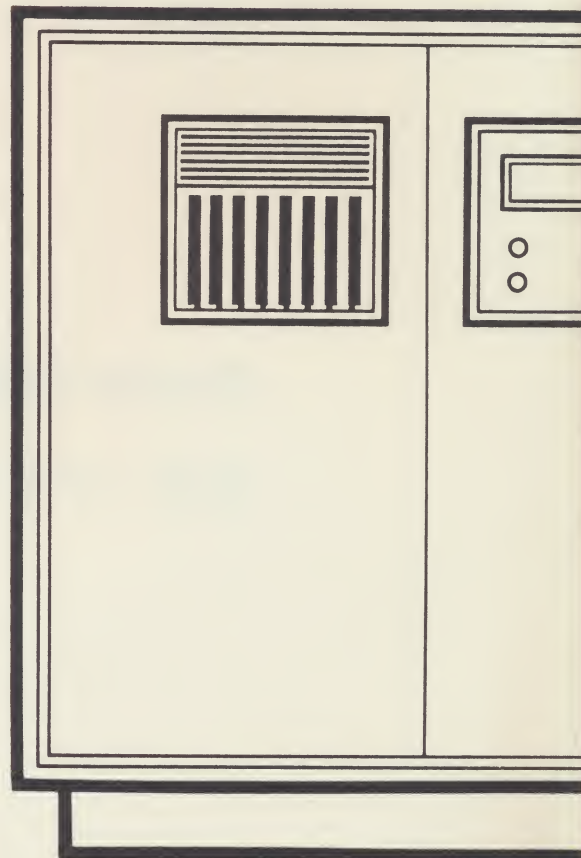
Unprecedented flexibility resulting from imaginatively conceived product packaging giving the utmost modularity and from the precision construction providing the capability for meeting many new and different customer specifications.

High per-unit capacity available in a broad spectrum of memories which meets almost every storage requirement. Capacities range from 100,000 bits (with a lightweight, custom-built, airborne, fixed-head drum) to 1,600,000,000 bits (with a large 25-data-disc file).

Better economy in terms of cost per bit stored. Bryant disc files range from 0.015 to 0.0082 cent per bit; drums from 3.23 cents per bit (smallest fixed-head) to 0.10 cent per bit (largest flying head)

see for yourself . . .

TECHNICAL DATA



**SERIES
4000
DISC
FILE**

BRYANT

COMPUTER PRODUCTS

A DIVISION OF EX-CELL-O CORPORATION

GENERAL INFORMATION AND SPECIFICATIONS
STANDARD BRYANT SERIES 4000 DISC FILES

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INTRODUCTION

Bryant Computer Products Division of Ex-Cell-O Corporation presents the Series 4000 Disc Files -- a family of production mass random access memories which have been thoroughly proven in many installations on a wide range of computer and data processing equipment.

Designed and built in the unique tradition of precision mechanical construction and sophisticated magnetic engineering that has made Bryant the leading independent manufacturer of disc files and magnetic drums, the Series 4000 Disc Files provide the optimum solution to the growing need for fast random access storage. High data transfer rates, low access times and modest cost are the most outstanding of their many features.

Three basic units make up the family, namely:

- . Series 4000A -- a memory which provides up to 390,000,000 bits using 600 BPI (bits-per-inch), block-format recording or 186,000,000 bits using 285 BPI, single-bit alteration recording.
- . Series 4000B -- a memory which provides up to 845,000,000 bits using 600 BPI, block-format recording or 403,000,000 bits using 285 BPI, single-bit alteration recording.
- . Series 4000C -- a memory which provides up to 1,625,000,000 bits using 600 BPI, block-format recording or 775,000,000 bits using 285 BPI, single-bit alteration recording.

Modularly constructed, the Series 4000 Disc Files are available in one-disc multiples ranging in capacity from 65,000,000 bits using 600 BPI, block-format recording

to 31,000,000 bits using 285 BPI, single-bit alteration recording.

All Series 4000 Disc Files are readily expandable in the field by adding modules until the maximum number of discs for each family has been reached. The "A" model has a capacity of six data discs (modules); the "B" model, a capacity of 13 data discs; and the "C" model, a capacity of 25 data discs.

Features and advantages of the whole family of Series 4000 Disc Files are as follows:

- . Widest range of capacities.
- . Fastest access time.
- . Series and parallel recording.
- . Unrestricted programming flexibility.
- . Optimized cylinder-mode operation.
- . Unrestricted record length.
- . Discrete clocked or self-clocked recording.
- . Wide operating temperature range.
- . Minimum maintenance.
- . Precision, digital head positioner.
- . Fast access channels available.
- . Fail-safe data protection in event of power failure.
- . Parallel operation without de-skewing registers.

GENERAL CONSIDERATIONS

Basic storage element in Bryant's Series 4000 Disc Files is a disc 39 inches in diameter which is coated on both sides with a proprietary magnetic oxide material. The "A" model employs from one to six of these discs for data storage; the "B", one to 13; and the "C", one to 25. All these files also include an additional clock disc.

Externally, the Series 4000 Disc Files appear as is shown in Figure 1; over-all dimensions are given in Figure 2. Discs in a given unit are rotated at either 900 or 1,200 rpm on a horizontal shaft cantilevered to facilitate the addition or removal of discs in the field, as is graphically illustrated in Figure 3.

Data Storage — Information is recorded within 768 concentric tracks on each disc face by six magnetic read/write heads. A digital hydraulic positioner moves the heads to any one of the 128 tracks accessed by each head.

One digital positioner is supplied for an entire file; thus, all heads on all disc faces are moved simultaneously. This action permits the use of an extremely efficient drum (or cylinder) operating mode in which each positioning operation accesses 1/128th of the full file capacity. In this mode of operation, the file can be pictured as 128 magnetic drums which means -- for a maximum capacity file -- each can store over 12,000,000 bits.

Access Time — Random access time within each drum or cylinder is extremely fast -- averaging 25 milliseconds -- because this period includes only disc latency, that is, the delay involved as a memory location rotates around to a position under the magnetic head. Positioning

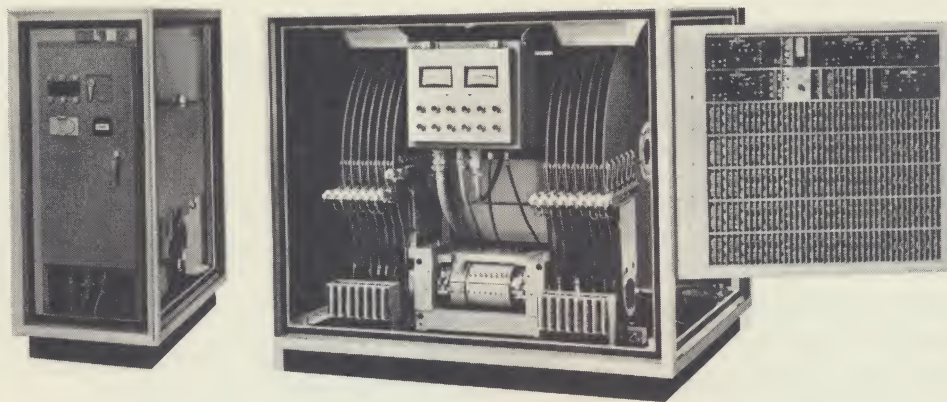
tracks are required, another clock disc can be supplied in place of a data disc on the "B" and "C" models.

Track Verification — Confirmation that the positioning system has moved the heads to the addressed track and that the heads have stabilized for read/write operation is provided in either of two ways at the user's option. Address data can be prerecorded in each track for comparison with applied addresses and, when a predetermined number of these compare successfully, a track verification signal is generated to initiate read/write operations. Alternatively, the address data can be prerecorded in the 128 tracks under one of the heads on the spare disc face. This one head, then, provides the track verification control for the entire file.

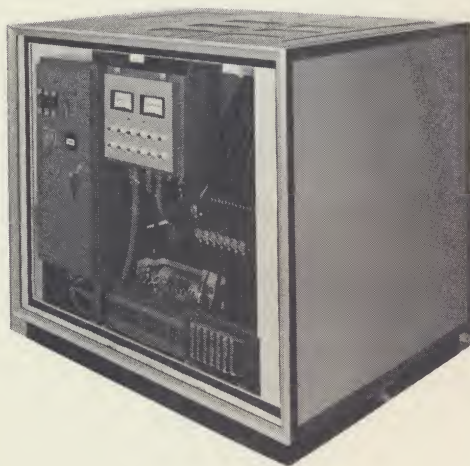
Both track verification techniques permit the computer to proceed with other operations once it has transmitted a new address to the file and until a track verification signal is received by the computer to indicate that the file is ready for read/write operations.

Quality Assurance — Long-term reliability and maintainability are built into all Bryant Series 4000 Disc Files. From the rugged mechanical structure to the precision of the discs and flying heads, the conservative design is keyed to long life, high reliability and ease of maintenance. Thorough testing and quality control procedures insure compliance of all components and of the complete system to rigid manufacturing and acceptance standards.

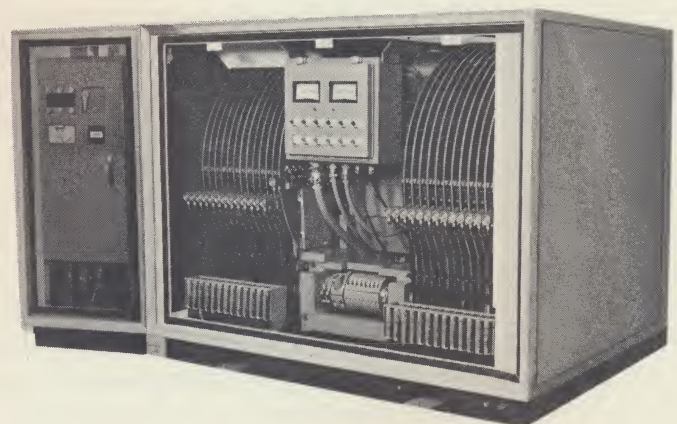
Operational Flexibility — The rigid precision construction of the Bryant Series 4000 Disc Files also provides unmatched operating flexibility. Block-format recording, which permits high packing densities, can be used to achieve large disc capacities. Self-clocking can be used to permit wider operating temperature ranges and to eliminate starting and warm up time requirements. Fully-clocked techniques can be used to permit single-bit alteration, bit interlacing, and parallel operation without de-skewing buffers.



"B"-SIZE DISC FILE



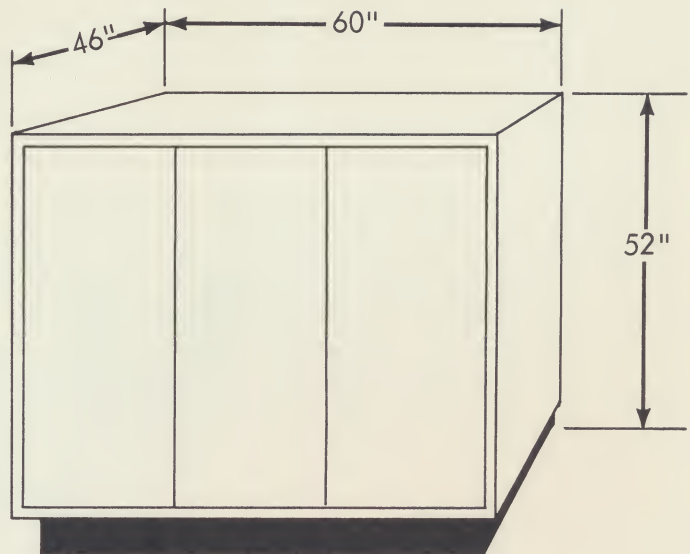
"A"-SIZE DISC FILE



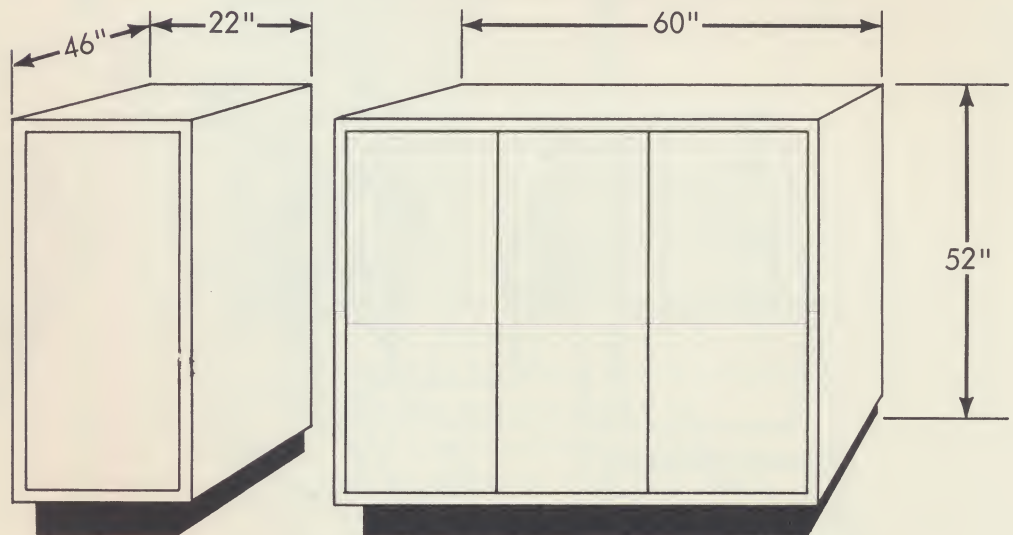
"C"-SIZE DISC FILE

FIGURE 1 - OVER-ALL VIEWS OF BRYANT SERIES 4000 DISC FILES. THE 6-DATA-DISC "A" MODEL IS A SELF-CONTAINED UNIT; THE 13-DATA-DISC "B" AND 25-DATA-DISC "C" MODELS HAVE SEPARATE CABINETS FOR THE POWER CONTROL UNIT AND THE DISC FILE ASSEMBLY

**"A"-SIZE
DISC FILE**



**"B"-SIZE
DISC FILE**



**"C"-SIZE
DISC FILE**

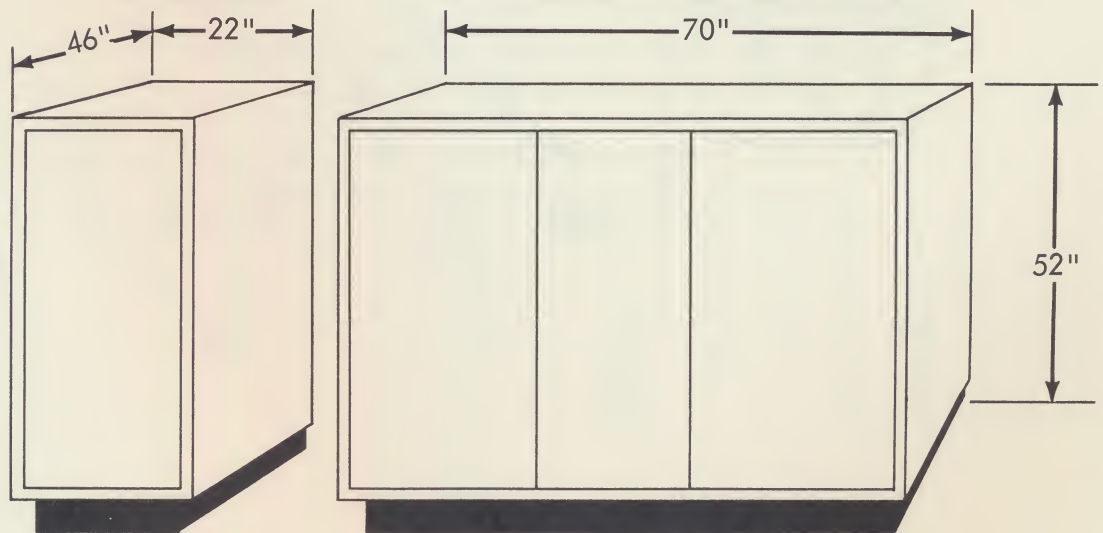


FIGURE 2 - EXTERNAL DIMENSIONS OF THE BRYANT SERIES 4000 DISC FILES

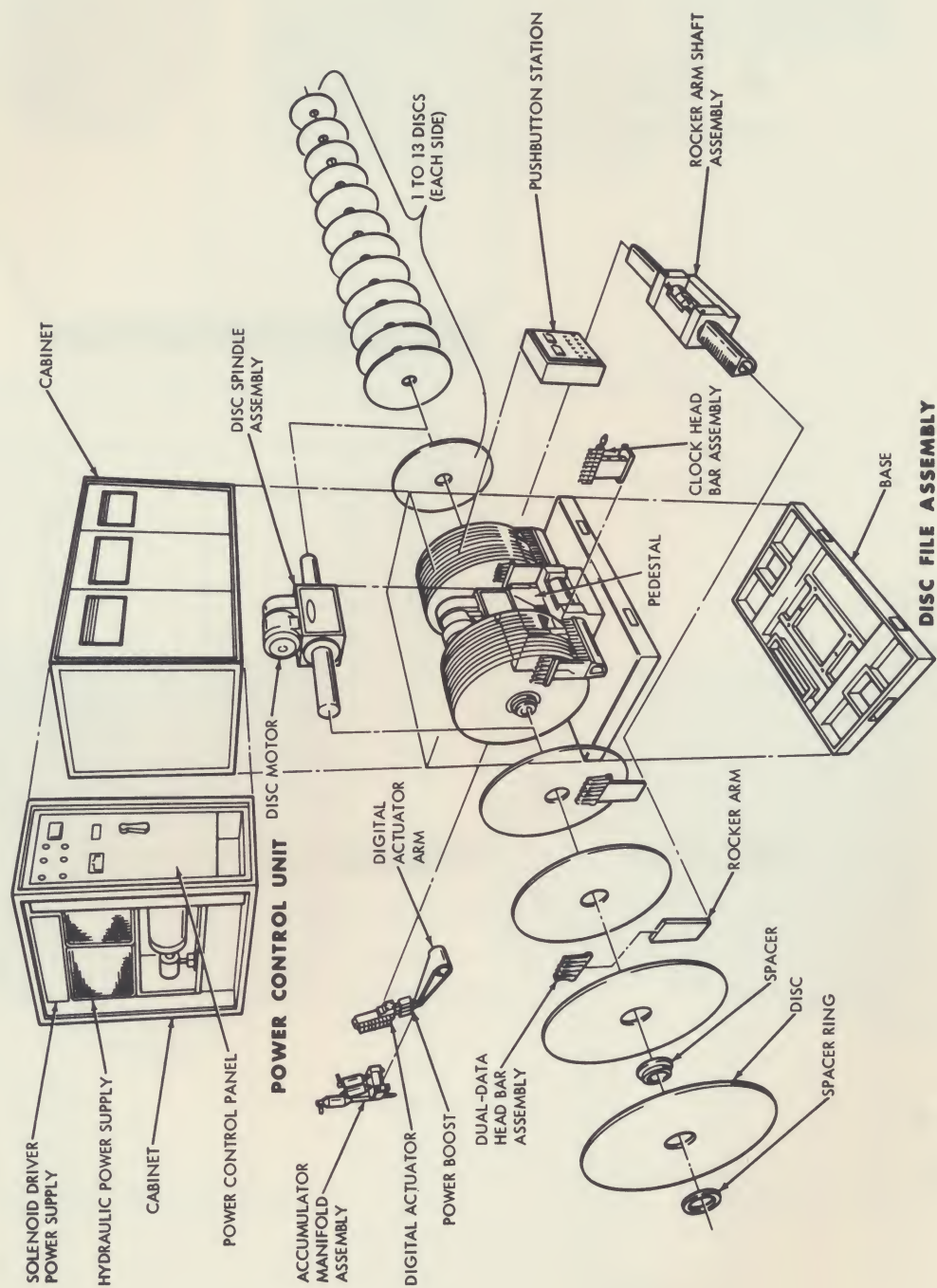


FIGURE 3 - EXPLODED VIEW OF A BRYANT SERIES 4000C DISC FILE

FILE ORGANIZATION

To maximize capacity while at the same time limiting the variety of recording frequencies, the 768 concentric tracks on each disc face are grouped in zones with all tracks in a zone having the same record length (or capacity) and frequency. Six zones -- one for each head -- is the maximum normally utilized, although each head could handle two or more zones merely by adding clocks. Typical six-, three-, two-, and one-zone arrangements are shown in Figures 4, 5, 6 and 7, respectively.

Track lengths of the zones can be related only in that they are all multiples of the basic record or word length, or they can be more intimately related. An outward zone can be divided into separately addressable channels of the same length and data frequency as an inward zone through bit interlacing as shown in Figure 8. Track lengths of the zones can also be arranged to achieve long storage blocks by adding tracks of two or more zones together in tandem as shown in Figure 9. A somewhat more complex relationship between track lengths frequently is required to satisfy the requirements of parallel systems; Figures 10 and 11 illustrate typical parallel arrangements designed to achieve specific data transfer rates.

Only one rule must be observed in laying out the discs to meet system requirements -- the maximum bit density recommended for the type of recording to be used should not be exceeded. Aside from this consideration, any layout which achieves the desired frequency, capacity and format is permitted. Table II gives the recommended

31,348,744-BIT CAPACITY PER DISC

Single-Bit Alteration Recording
Recording Density: 285 BPI (nominal)

65,720,832-BIT CAPACITY PER DISC

Block-Format Recording
Recording Density: 600 BPI (nominal)

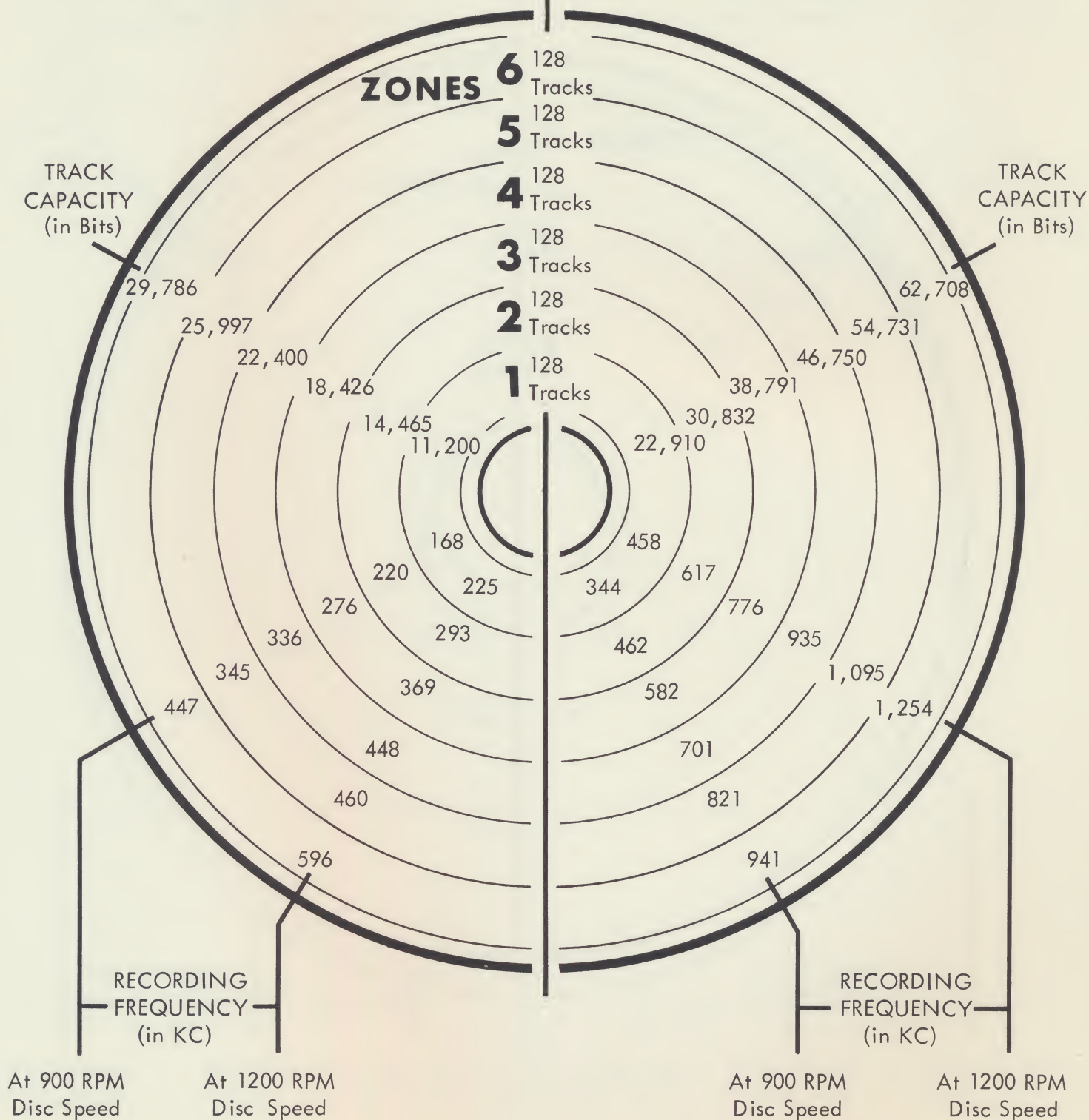


FIGURE 4 - MAXIMUM CAPACITIES OBTAINED WITH SIX-ZONE DISC FORMAT.

28,478,976-BIT CAPACITY PER DISC

Single-Bit Alteration Recording
Recording Density: 285 BPI (nominal)

59,613,184-BIT CAPACITY PER DISC

Block-Format Recording
Recording Density: 600 BPI (nominal)

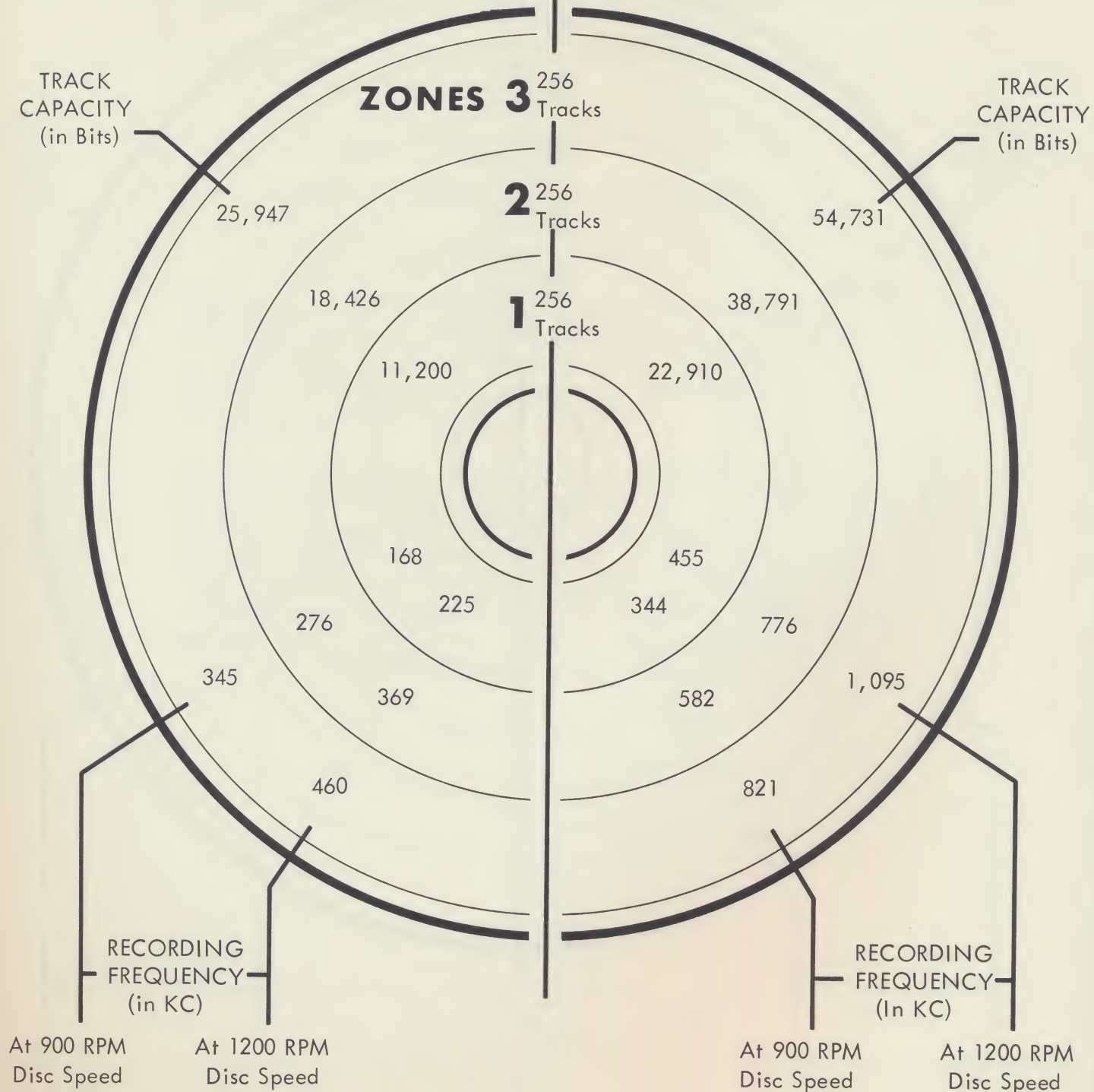


FIGURE 5 - MAXIMUM CAPACITIES OBTAINED FROM THREE-ZONE DISC FORMAT.

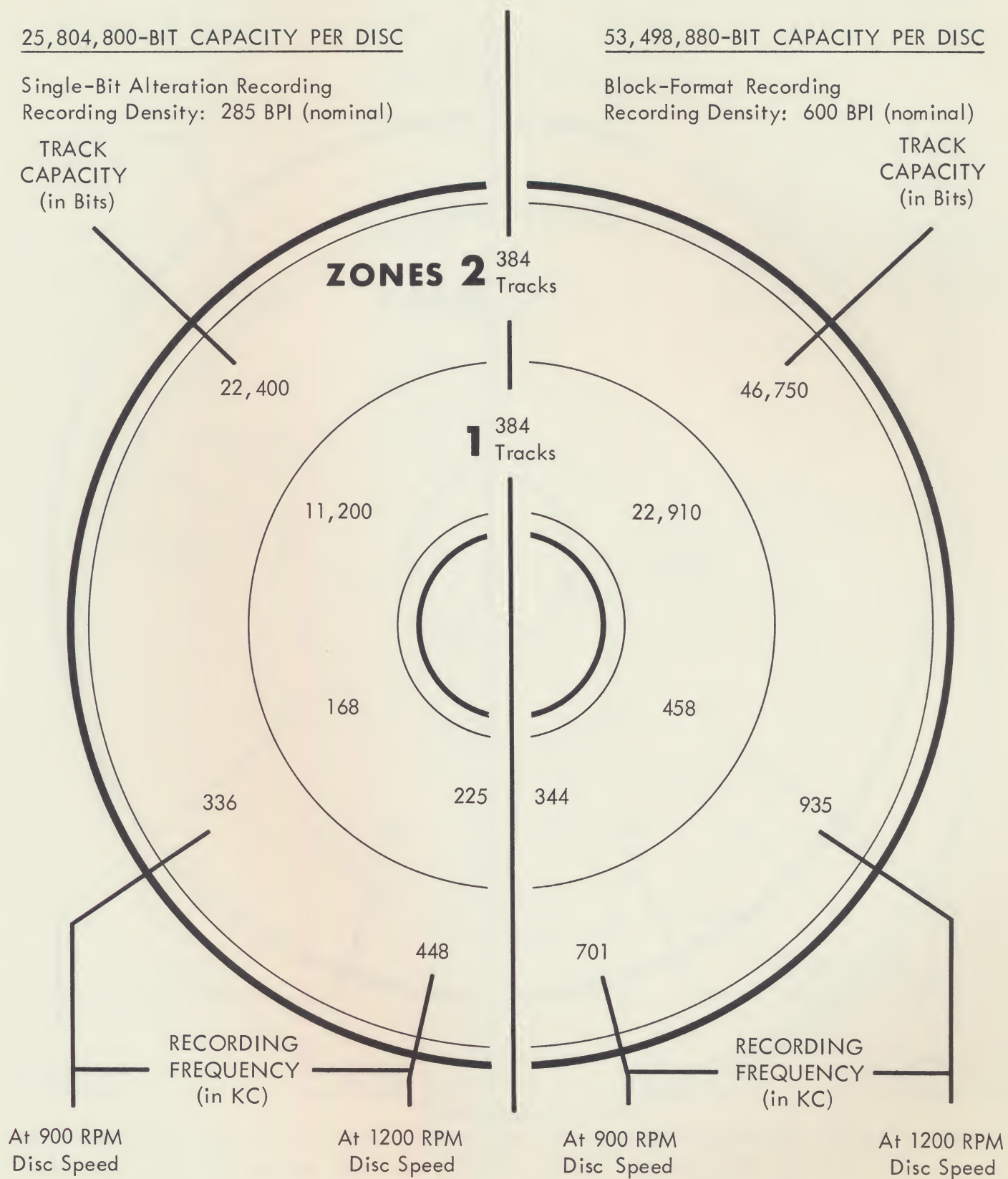
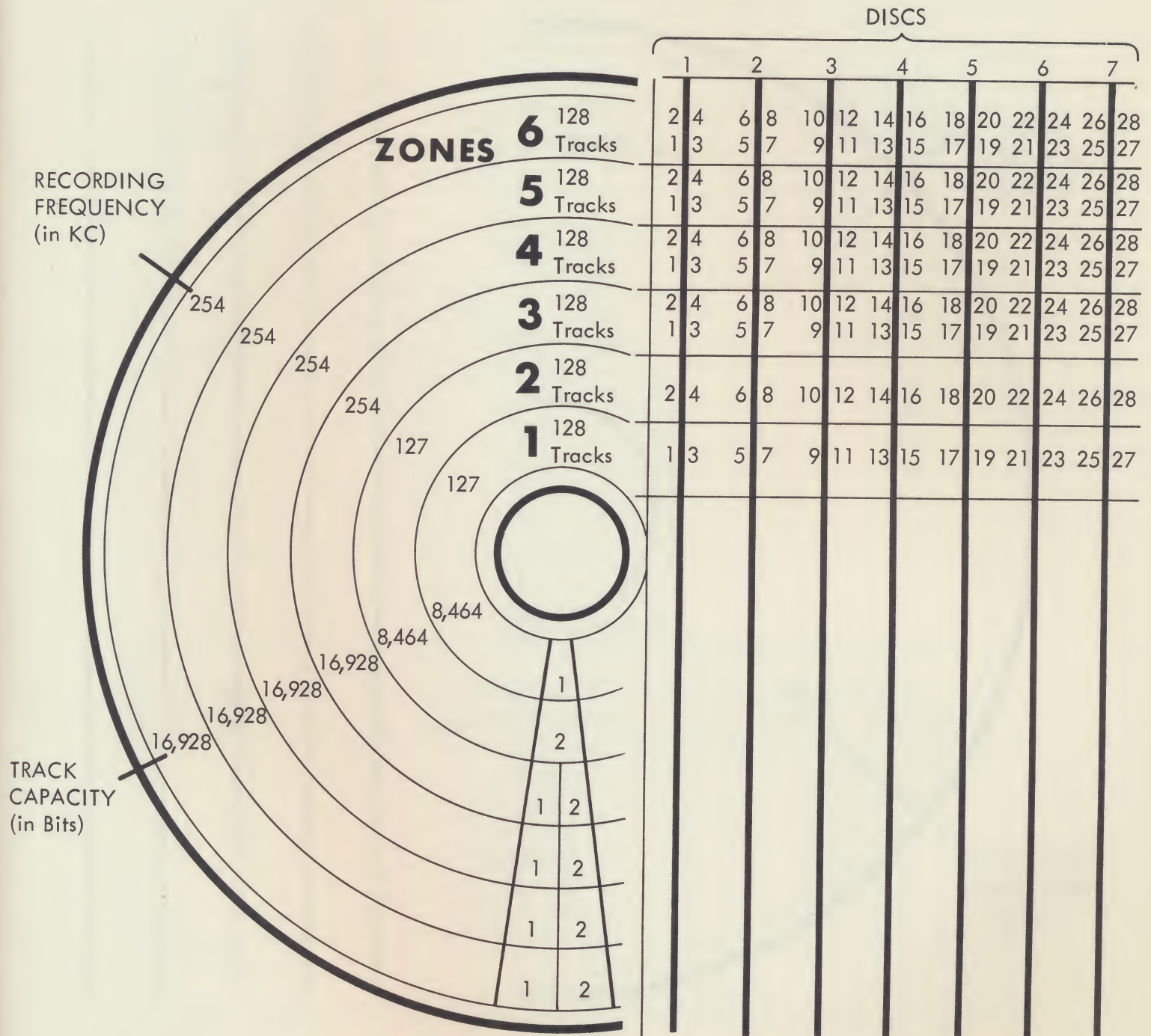


FIGURE 6 - MAXIMUM CAPACITIES OBTAINED WITH TWO-ZONE DISC FORMAT

21,667,840-BIT CAPACITY PER DISC (at 900 RPM)

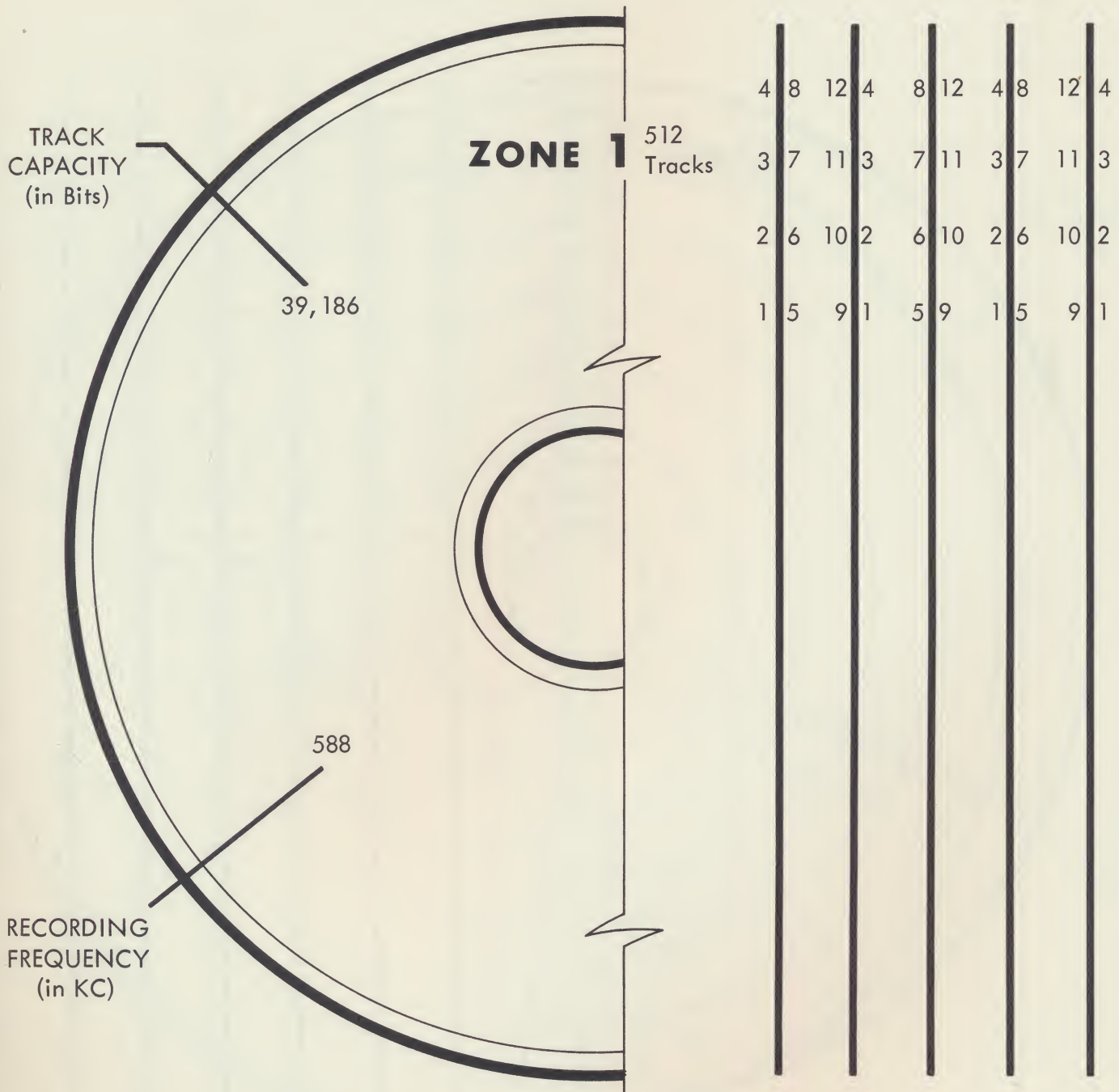
Parallel-Format Recording
Recording Density: Zone Variable



Note: Zones 1 and 2 are used together to achieve 28-bit parallel recording across 14 disc surfaces (7 discs). Zones 3, 4, 5 and 6 are used individually to the same end at double the frequency of zone 1 or 2.

FIGURE 10 - TYPICAL 28-BIT PARALLEL DISC FORMAT

Parallel-Format Recording
Recording Density: 600 BPI (nominal)



Note: Only four heads used per disc surface. Twelve heads on three surfaces operate in parallel.

FIGURE 11 - MAXIMUM CAPACITIES OBTAINED WITH 12-BIT PARALLEL, HIGH-DENSITY DISC FORMAT

TABLE II - CAPACITY AND FREQUENCY DATA FOR BRYANT SERIES 4000 DISC FILES

DISC CAPACITY

	285 BPI	600 BPI
6 Zones	31,348,744	65,720,832
2 Zones	25,804,800	53,498,880
1 Zone - 4 Heads	18,868,224	39,721,984

TRACK CAPACITY

ZONE	INNERMOST TRACK LENGTH (in inches)	TRACK CAPACITY AT 285 BPI (in bits, nominal)	TRACK CAPACITY AT 600 BPI (in bits, nominal)
1	38.183	11200	22910
2	51.386	14645	30832
3	64.652	18426	38791
4	77.918	22400	46750
5	91.219	25997	54731
6	104.513	29786	62708

ZONE CAPACITY

ZONE	TOTAL BITS (285 BPI, nominal)	TOTAL BITS (600 BPI, nominal)
1	1,433,600	2,932,480
2	1,874,560	3,946,496
3	2,358,528	4,965,248
4	2,867,200	5,984,000
5	3,327,616	7,005,568
6	3,812,608	8,026,624

RECORDING FREQUENCY (in KC, nominal)

ZONE	285 BPI		600 BPI	
	900 RPM	1200 RPM	900 RPM	1200 RPM
1	168	225	344	458
2	220	293	462	617
3	276	369	582	776
4	336	448	701	935
5	345	460	821	1,095
6	447	596	941	1,254

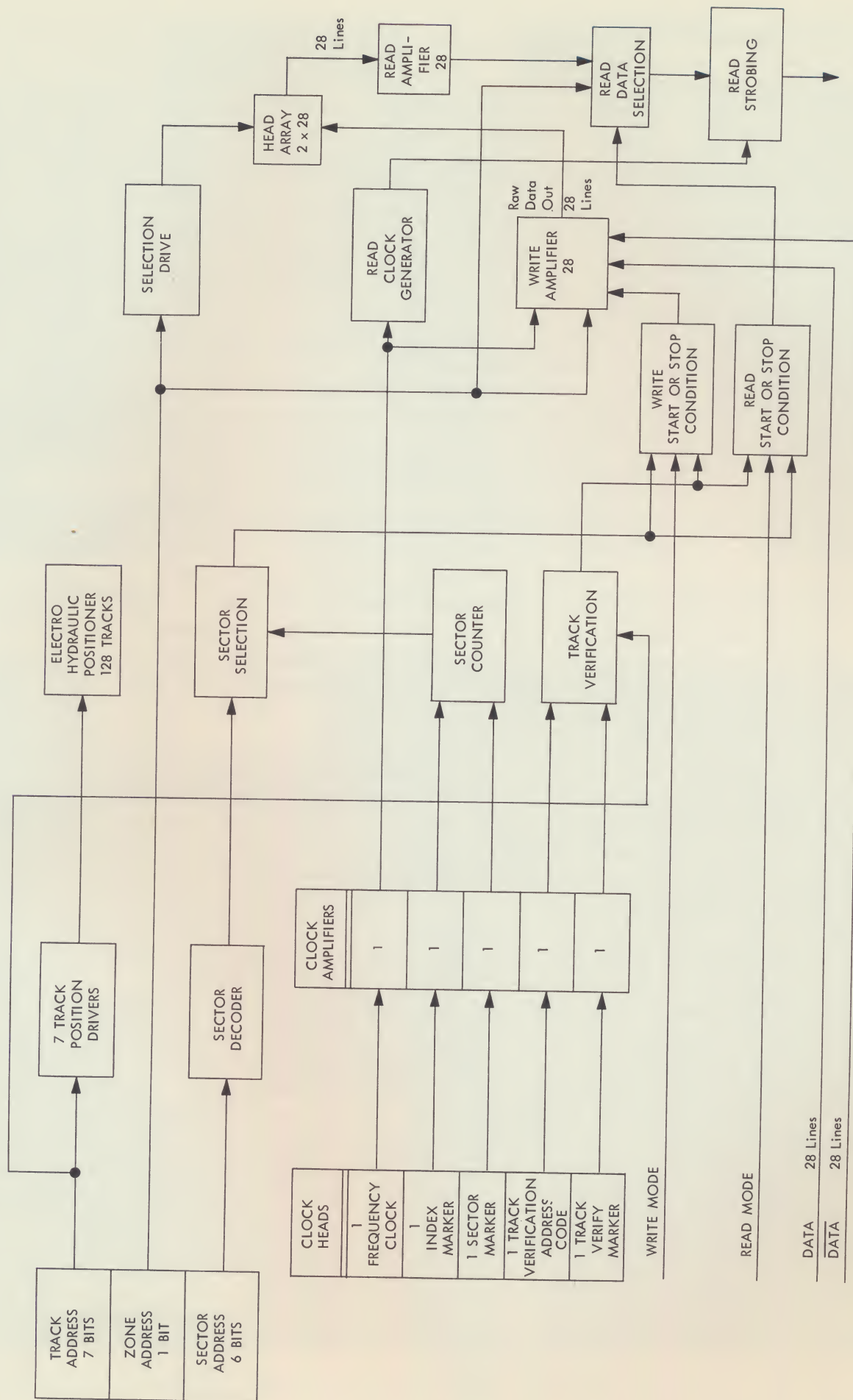


FIGURE 13 - TYPICAL 28-BIT PARALLEL SYSTEM FOR A 6-DATA-DISC
SERIES 4000A DISC FILE

MAGNETIC HEADS

Aerodynamic read/write heads (see Figure 14) used with the Series 4000 Disc File are standard Bryant magnetic head structures in an aerodynamic head body which flies on a laminar film of air produced alongside the disc as it rotates. All heads include centertapped, balanced coils. No erase head is required because the Bryant positioner is a reliable precision-built device -- instead, old information can be erased simply by writing new information over it. Each head body is mounted on a self-aligning, precision axle; the head face adjacent to the disc is provided with an optically lapped surface of low-friction material. (Complete head performance data are available in Bryant Specification ES-174.)

Each head axle is mounted in the free end of a spring reed which normally urges the head away from the disc face. The twelve data heads accessing the opposite faces of adjacent discs are supported on a single head bar. Individual data head bars with only six functional heads are provided for the outer faces of the end discs.

All data heads on a bar are urged toward the discs and into their "flying" position by hydraulic actuator which activates a cam slide on the bar. Safety interlocks retract the heads instantly in the event of a power or drive system failure. Individual adjustments are provided to control the camming action on each data head.

Clock heads (see Figure 15) are mounted on a head bar similar to that used for data heads, but which supports a maximum of eight head pad assemblies, each incorporating one or two clock or fast-access channel heads. The clock head bars unlike data head bars, are rigidly supported on the center pedestal with their heads flying on the innerface of the inside disc. A total of 32 heads for clocks and fast access can be provided, 16 on each inside disc face.

POSITIONING SYSTEM

Differential movement of the rocker arm shaft used to selectively position the magnetic heads is achieved by a unique, open-loop, mechanical/hydraulic actuator through a backlash-free linkage. The actuator produces linear movements to swing all of the head bars simultaneously to any one of 128 positions with a long-term accuracy of better than 0.001 inch.

The positioning system consists of a digital actuator and a power boost (see Figure 16). The actuator incorporates a housing containing seven separate piston and cylinder assemblies in a common bore, each controlled by a solenoid valve.

When the actuator is energized, the solenoid valve gates hydraulic fluid to the pistons to extend or retract them as dictated by a seven-bit, logic-level binary address. Precision stops restrict the movement of the pistons within their cylinders to distances proportional to the binary values 1, 2, 4, 8, 16, 32 and 64. However, each piston carries with it -- as it is extended and retracted -- all of the cylinder-piston assemblies ahead of it. Thus, the movements of the pistons are additive and 128 discrete settings can be obtained.

The 128 discrete settings produce differential positioning of a servo valve spool in the power boost which attempts to set the boost piston accordingly. However, because the piston is fixed, the boost housing is forced to follow the servo valve spool to each of its 128 positions. Movements of the power boost are transmitted to the heads through a rigid actuating arm pivoted to the boost and secured to the rocker arm shaft.

RELIABILITY

Exacting design philosophies, rigid manufacturing specifications, stringent quality control procedures and exhaustive testing are all utilized to ensure inherent reliability of each Bryant Series 4000 Disc File. Reliability, however, is not merely a built-in characteristic of the equipment -- it is also a function of the manner in which the equipment is operated and of the quality of maintenance provided.

Checkout Procedures -- The simple operating procedure of performing a read check after each write operation and re-writing, if necessary, greatly improves system reliability. Without this procedure, a single write error may appear as any number of read errors when the data are accessed time and again. The practice of re-reading following a read error and proceeding, if the error is not repeated, also increases reliability.

Recording Techniques -- Methods of recording on discs and of detecting the recorded intelligence also have a profound effect on reliability. Phase-modulation recording provides high signal-to-noise ratios, and therefore, improves reliability. Return-to-bias recording produces less deterioration of adjacent bits in single-bit alteration recording, but is more susceptible to the effects of noise. Threshold detection techniques are simple and straightforward, but can only accommodate modest variations in signal amplitude; however, peak-detection or zero-crossover-detection techniques can accommodate wide variations in signal amplitude. Fully-clocked techniques -- required for single-bit alteration -- are subject to timing problems resulting from temperature changes; self-clocked techniques eliminate this problem.

Obviously, the stringent functional requirements of single-bit alteration recording necessitate the use of recording and detection techniques which are more sensitive than those sufficing for block recording and which, when exposed to the same environment, exhibit somewhat poorer reliability. For

Mean-Time-To-Failure** -- The mean-time-to-failure of Bryant Series 4000 Disc Files now in operational use also varies in accordance with the size of the file, the complexity of the file electronics, the mode of file operation, the method of recording and the quality of maintenance. Up to 3000 hours mean-time-to-failure has been achieved in customer installations.

*Recoverable errors are defined as those which are corrected automatically by the equipment without operator intervention using read-after-write, read-after-read and similar error recovery techniques.

**A failure is defined as any equipment malfunction which interrupts scheduled file operation whether data is lost, or is recoverable by equipment adjustment or replacement.

inspection is made for surface defects before the discs are moved along to the electrical testing facility. Electrical tests are made on an automatic digital system which writes binary ONES and binary ZEROES on the discs and compares the resultant playback with specified standard criteria. Radially overlapping tracks are written to ensure thorough testing of the complete surface. Discs passing this test are then balanced and installed on a production disc file.

Magnetic Heads -- The product assurance program for magnetic heads starts with complete specifications on the physical dimensions, and electrical and magnetic characteristics of the components. One hundred percent inspection is made on all components. Rigid batch and lot control is exercised on the ferrite pole pieces. One hundred percent in-process inspection is made during the assembly of the basic head.

All head assemblies are tested for physical compliance to specifications and then are qualified as to aerodynamic and recording capabilities on a standard disc in a test fixture. Heads passing these tests are assembled in head bars which are then qualified as assemblies on standard discs in a test file. Acceptable head bars are then installed on production files and are completely retested using the discs with which they are to work.

Digital Actuator -- The product assurance program for the digital actuator and boost begins with specifications of the materials, hardness, finish and precision dimensions. One hundred percent incoming and in-process inspection is made. Each solenoid valve is tested as an assembly; positioner and boosts are tested as complete assemblies on hydraulic test stands. Positioner and boost combinations are cycled many thousands of operations in all combinations of positions to ensure accuracy, speed of operation, repeatability of movement and tightness of seals. Acceptable positioners and boosts are

installed on files and are given an additional 16 hours or more of continuous cycling through all positions to ensure accuracy, speed, repeatability and seal tightness of the complete systems.

Similar product assurance programs are in force for all major assemblies and subassemblies.

Final Testing -- Final testing of a completely assembled disc file is accomplished in two phases. First, a 40-hour preliminary test is used to check all of the functions and features of the file using a variety of automatic test and exercise equipment. All automatic and manual controls are tested, exhaustive positioning tests are run, all heads are checked, test recordings are made to check the integrity of the disc-head-positioning systems, environmental checks are accomplished, start-and-run power readings are taken, all meters are checked and the hydraulic supply system is tested.

Finally, the entire file is tested dynamically on the customer's computer using operational programs to exercise the file through all its operating modes. An eight-hour test exercising all the file's capabilities is recommended, followed by a three-day stability test simulating normal operational file usage.

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PHILADELPHIA, PENNSYLVANIA

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COCOA BEACH, FLORIDA

Medco of Melbourne, Inc.
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